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Technical Report 729

Land Navigation Skills Training: An Evaluation of Computer and Videodisc-Based Courseware

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U. S. Army

Research Institute for the Behavioral and Social Sciences

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This research effort evaluated the training effectiveness of computer and videodisc-based courseware developed for training basic land navigation skills. The land navigation skills addressed by the courseware included the identification of natural terrain features, map-terrain association for orienting a map and determining a location, intersection, resection, and terrain analysis. The evaluation used a pretest-posttest design, and all training and tests were delivered on-line by the computer (Continued)

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delivery system. Control conditions were included to ensure that improvements on posttest measures were due to training effectiveness rather than participants' increased familiarity with test formats and the computer delivery system. Results for three of the tasks--Intersection and Resection, Identify Terrain Features, and Terrain Analysis--showed significant improvement in posttest performance and raised participants from a pretest average of "NO GO" to a posttest average of "GO." Results for these tasks also showed the courseware to be more efficient than conventional training methods and user friendly. For the other two tasks--Orient a Map and Determine Location by Map Terrain Association--courseware design modifications are needed and design recommendations are discussed.

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Land Navigation Skills Training: An Evaluation of Computer and Videodisc-Based Courseware

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FOREWORD

The principal mission of the Training Research Laboratory of the Army Research Institute is to refine the Army's training methods and practices. As part of this refinement, the ARI-Fort Knox Training Technology Field Activity's (TTFA) mission is to develop, evaluate, and implement new technologies and methods into Army training. This TTFA's recent efforts have focused on the potential of computer and videodisc-based technologies for Armor training.

This report provides a description and evaluation of an initial TTFA product, computer and videodisc-based courseware for training land navigation skills. Successful implementation of this courseware in the M1 tank commanders course, 19K BNCOC, would support the transfer of automated training technologies into the Army training system.

Edgar M Johnson

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LAND NAVIGATION SKILLS TRAINING: AN EVALUATION OF COMPUTER AND VIDEODISC-BASED COURSEWARE

EXECUTIVE SUMMARY

Requirement:

To evaluate the effectiveness of the computer and videodisc-based courseware developed for training basic land navigation skills.

Procedure:

As part of the Training Technology Field Activity (TTFA) mission to provide innovative training technologies for Army training, computer and videodisc-based instruction was developed for training and testing basic land navigation skills. The training effectiveness of this courseware was evaluated with a sample of 44 military personnel similar to soldiers in the M1 tank commanders course, 19K Basic Noncommissioned Officer Course (BNCOC). All training and tests were delivered on-line by a MicroTICCIT System II computer delivery system. A pretest-posttest design with several control conditions was used to determine the courseware's training effectiveness.

Findings:

The courseware's training effectiveness for three of the tasks--Identify Natural Terrain Features, Locate an Unknown Point on the Ground by Intersection or Resection and Analyze Terrain Using the Five Military Aspects of Terrain--was demonstrated by significant improvements in participants' posttest scores, and an average increase for the sample from pretest "NO GO" to posttest "GO." In addition, the findings demonstrated that the courseware was more efficient than the conventional instruction and user-friendly.

For the other two tasks--Orient a Map and Determine Location by Map Terrain Association--the design of the courseware was found inadequate and design modifications were recommended.

Utilization of Findings:

The findings of this evaluation were provided to the Technical Director of the Armor School who recommended validation of the courseware found effective in the 19K BNCOC program of instruction. Successful implementation into this course would support the transfer of this courseware to other Army training systems.

LAND NAVIGATION SKILLS TRAINING: AN EVALUATION OF COMPUTER AND VIDEODISC-BASED COURSEWARE

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INTRODUCTION

While the Army training system has incorporated numerous new technologies in recent years, it is still heavily dependent upon approaches from an earlier era, such as use of paper materials and classroom lecturing techniques. In an operational training environment it is difficult to systematically test and apply promising technologies and innovations, especially given the rapid rate at which technologies are being developed today.

To overcome this difficulty, the U.S. Army Training and Doctrine Command (TRADOC), the US Army Armor Center (USAARMC), and the US Army Research Institute (ARI) have established the Training Technology Field Activity (TTFA) at Fort Knox, Kentucky. The mission of the TTFA is to systematically identify, evaluate, and introduce new training methods, techniques, technologies, and models to Army training. A more complete discussion of TTFA's background, approach and scope of effort is provided by Kristiansen (1986).

The initial efforts of the Fort Knox TTFA have focused on the Basic Noncommissioned Officer Course (BNCOC) training program for M1 tank commanders with the Military Occupational Speciality (MOS) 19K. A review of BNCOC performance records and interviews with BNCOC instructors identified land navigation as one of the most difficult training problems in the BNCOC program of instruction (POI). This paper reports the development and evaluation of the TTFA'S courseware for this block of instruction, land navigation skills training.

Background

The difficulties inherent in land navigation training and performance are not recent and certainly not limited to the area of Armor operations. In the late 1950's, the Army commissioned a series of land navigation research efforts which were conducted at Fort Knox with Armor personnel (Findlay, Roach, and Logan, 1957; Logan, Willmorth, and Findlay, 1957; McGuigan, 1957; Willmorth and Logan, 1957). This work resulted in a number of useful recommendations for the training of land navigation skills--but a conclusion that land navigation is a very difficult task to train, and skill to acquire. For example, out of 96 soldiers who had completed basic combat training and received a two hour review of map reading skills before testing, 83 percent failed half of their six field navigation missions and 17 percent failed on all six missions tested (Findlay et al. (1957).

Later and in a different training setting, infantry soldiers at Fort Benning, 50 percent failed to reach their objective over terrain routes rated as "easy" to "moderate" and only 5% reached the objective when navigating over "difficult" routes (Powers, 1964). While field-based research in land navigation has drastically declined in the last two decades, a review of the more recent literature reveals little improvement in the performance of land navigation tasks by military personnel (Cross, Rugge, and Thornydke, 1982; Pleban and Grainer, 1985).

APPROACH

Component Skills

The courseware in question focused on a subset of the basic skills required for tactical land navigation. A more complete set of the component skills required for land navigation is provided by Findlay et al. (1957) and Powers (1964). Tasks included in the current courseware were selected by the Land Navigation Steering Committee. This committee was established by the TTFA to ensure that the courseware's training objectives were coordinated with the appropriate military training and doctrine agencies. The committee included designated representatives from the NCO Academy, the Directorate of Training and Doctrine (DOTD), Training Group, and instructors from the M1 tank commanders course, 19K BNCOC. In conjunction with ARI and the supporting contractor, the Steering Committee's final selection of tasks to be included was based on current training and performance deficiencies, and the feasibility of using computer based instruction (CBI) for training and performing each task (Knerr, Sticha, Ramsberger, Harris, and Tkacz, 1984). The following tasks were selected for courseware development:

1. Identify natural terrain features and determine elevation.
2. Orient a map to ground by map-terrain association.
3. Determine location on the ground by terrain association.
4. Locate an unknown point on a map or on the ground by intersection or resection.
5. Analyze terrain using the five military aspects of terrain.

The tasks selected are expected to provide the most important skills required for tactical land navigation. In their earlier study, Findlay et al. (1957) identified contour visualization and direction estimation as the most critical subset of tasks required for daylight land navigation. The first three tasks selected stress map-terrain association and directly focus on the contour visualization problem. The fourth task, intersection and resection, addresses direction estimation. The final task, terrain analysis, requires the application of these basic skills in a tactical setting. Before describing the courseware developed for training these component skills, a brief discussion of each task and topographical map "reading" requirements is presented.

The heart of the land navigation problem is the difficulty of deciphering the information that is encoded on topographic maps. A topographic map is a depiction of the natural and man-made features, from a small region of the earth's surface, that includes their relative elevation and location. As McGrath (1977) has documented, the navigator's primary task requires the inferential skills of map interpretation, rather than merely map reading. The cartographer's rules for exclusion, inclusion and representation of both natural and man-made features cannot result in a map that is the same as the earth's surface. As noted by Rogers and Cross (1979) a map is a stylized, simplified, generalized and codified presentation of a selected sample of some of the characteristics of the earth's surface.

Map-Terrain Association. Compounding the navigator's task is the requirement for contour line interpretation to visualize the actual shape and height of the landforms depicted, the terrain's relief, as depicted on a topographic map (see Figure 1). The contour lines connect the points on the map's surface that have the same elevation. Terrain relief is not only the most pervasive and unique of all topographic features, it also carries great tactical significance. Yet empirical tests of the contour-interpretation skills of experienced military personnel (i.e., Farrel and Potash, 1979; Rogers and Cross, 1979) frequently disclose performance levels only slightly greater than chance, and for many "navigators" a complete inability to visualize the lay-of-the-land as depicted by their map's contour lines.

Direction Estimation. More precise skills for determining one's position or the location of an unknown point are resection and intersection, respectively. The location of an unknown point, or terrain feature, that is not depicted on the map, can be determined by plotting onto a topographical map the azimuths taken from two or more locations to that point. The intersection of these azimuths pinpoints, or fixes, the feature's location. To determine one's own position, the resection of azimuths plotted from two or more features depicted on the map identifies one's current location. Either compass readings or line-of-sight, straight-edge readings may be used for plotting an azimuth. But given the unreliability of compass bearings in an Armor environment, the current courseware addressed the straight-edge method. Again the training and performance deficiencies associated with intersection and resection are considerable. For example, Dewey and O'Hanlan (1986) in a resection exercise involving 12 soldiers and 3 different locations reported an average error of 682 meters, compared with a military task standard of $\pm$ 100 meters.

Terrain Analysis. The final task included in the land navigation courseware, terrain analysis, requires the application of map reading skills to a tactical assessment of the terrain. An analysis of the terrain requires the consideration of tactical concerns such as cover, concealment, observation, and avenues of approach. Ideally, this analysis is conducted while performing an on-site reconnaissance of the area, but the presence of enemy forces may preclude direct observation of the terrain. In this latter case, map reconnaissance, the terrain analysis requires a high level of contour visualization.

Skill Generalization. A final consideration in the development of land navigation training is the problem of skill generalization. The Armor force in particular must be prepared to carry out rapid, coordinated land maneuvers in many different geographic settings. Yet conventional

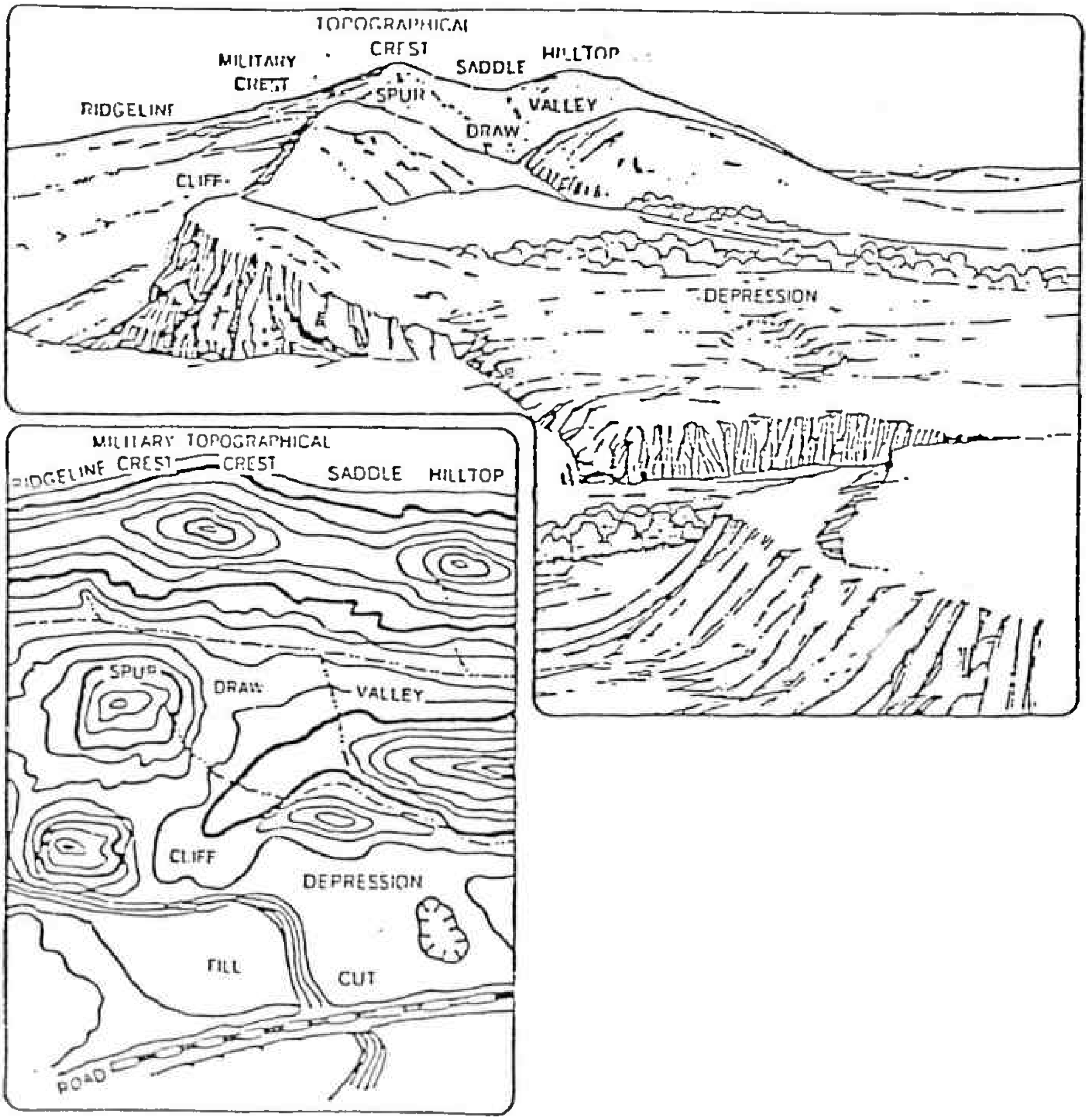

Figure 1. Comparison of topography (upper portion) and topographical map (lower portion).

land navigation training, and especially the field training, is inevitably limited to the terrain features and landforms indigenous to the training locale.

Training Technologies

As part of TTFA's mission to implement innovative training technologies into Army training, the land navigation courseware was designed and developed as computer-based instruction. The positive instructional characteristics associated with CBI such as reliability, standardization, cost effectiveness, interactivity and immediate feedback have been well articulated (e.g., Ellis, 1986; Heinich, 1985; Orlansky and String, 1981). A more innovative technology included in the courseware design was the use of videodisc imagery for depicting live-action modeling of task performance and dynamic real-world terrain scenes. Interactive video provides a number of unique features such as fidelity of visual and audio training materials, random and rapid access, multiple speeds and directions, and the potential for interactive and individualized instruction. A more complete discussion of the merits of interactive video, beyond the current scope, is available (Hannafin, 1985; Reigeluth & Garfield, 1984).

With respect to the current TTFA implementation, instructional experts suggest that interactive video may be particularly effective in applied training settings (Woolley, 1982) and in solving troublesome training issues not resolved by conventional training methods (Thorkildson, 1983). In summary, an interactive, multimedia training package was developed by interfacing the computer-based instructional materials, text and graphics, with supporting videodisc-based materials, both video and audio.

Design of the Courseware

The courseware materials and instructional methods were designed and tailored to provide innovative solutions to the terrain visualization and contour interpretation problems discussed earlier. In particular the transition from the two-dimensional surface of the topographic map to the three-dimensional world of natural terrain features and landforms represents a demanding and nonintuitive set of spatial and cognitive transformations. For example, the inclining terrain associated with spurs is portrayed by declining or U-shaped contour line patterns, and conversely the lower ground associated with draws is depicted by inclining or inverted U-shaped contour patterns (See Figure 1).

To facilitate these cognitive transformations, a landform model was developed for this courseware that included various terrain features such as hills, ridgelines, draws and spurs. This three-dimensional terrain model was then annotated with the appropriate contour patterns. Video sequences of the model were developed that slowly shifted and reshifted from the overhead or "birds-eye" two-dimensional view associated with map portrayal to the horizontal, linear perspective associated with a direct view of the terrain. It was anticipated that by being able to shift or would be provided unlimited practice at making the required perceptual transformations.

Special effort was also taken to provide soldiers in a classroom setting a more dynamic view of real-world terrain. Capitalizing on the rapid access time of videodisc, photographs of the terrain were taken that allowed students to pan across a 360-degree view of the terrain and to zoom in for close-up views of this terrain in any direction.

Finally, the use of videodisc terrain scenes not only provided soldiers high-fidelity landscape views, but a relatively low-cost solution to the problem of non-generalized land navigation training and skills. The courseware included multiple terrain scenes from the Southwest's Mojave desert, the hilly regions of Northern Virginia, and the on-site terrain of Fort Knox, Kentucky. Soldiers could therefore be trained and tested on a cross-sample of very different geographic regions which were all supported by either standard 1:50,000 military maps or U.S. Geological Survey topographic maps. Additional terrain scenes could be added to the courseware content to prepare soldiers for more precise, mission-specific, regions.

Objectives

The basic research question was to determine the training effectiveness of the computer and videodisc-based land navigation courseware. It was hypothesized that the courseware would significantly increase soldiers' posttest scores, above their pretest scores, for each of the five land navigation tasks addressed by this courseware. Two control conditions were included to counter the alternative hypotheses that posttest increases may have been caused by soldiers' increased familiarity with the pretest items and the courseware delivery system, due to each participants approximately three hours of testing and training. Additional research issues were to evaluate the courseware's training efficiency, in terms of time required to complete the training, and the ease-of-use soldiers experienced with the courseware.

METHOD

Participants

Participants for this research were E3-E5 personnel stationed at Fort Knox with either an Armor (MOS 19K) or a Calvary (MOS 19D) military background. They were selected as a sample representative of the soldiers that might receive this courseware in the formal program of instruction (POI) for the M1 tank commanders, 19K BNCOC. Six participants were included in a pilot test of the land navigation courseware and experimental procedures. Fourty-four soldiers, the land navigation group, participated in the formal evaluation. An additional 39 soldiers, the remedial group, served as a control group for this evaluation. Participants from both of these groups averaged just over 3 years of military service, with a range of 1 to 8 years. They also averaged 23 years of age, with a 19 to 30 year range. Almost all (93%) participants had completed high school, and nearly one out of four had completed some college courses. Most of them reported to have little or no computer experience. In general, both samples appeared representative of 19K BNCOC attendees. Due to the formative aspects of this evaluation and the limited number of student work stations available, it was decided not to disrupt the BNCOC course cycle by using students currently enrolled in 19K BNCOC.

Apparatus

The CBI for this evaluation was supported by a MicroTICCIT (System II) host computer networked to the student work stations. Each workstation included the following hardware:

- IBM PC 256K bytes RAM
- 12" Sony color monitor
- Sony videodisc player 1000 or 1000A
- Light pen and stereophonic headset

All courseware was developed using the MicroTICCIT's ADAPT, level three, authoring language. Soldiers were randomly assigned to one of the three student workstations available for this evaluation. In addition, students at each station were provided a set of paper copy topographic maps, and a stereophonic headset to ensure a direct link with the auditory portions of the instruction and to reduce the probability of students being distracted by any ambient noise.

Design of the Evaluation

The independent variable in this evaluation was the land navigation training as presented by the computer and videodisc-based courseware. The dependent measure was the overall gain score (posttest minus pretest) for each of the five land navigation tasks. T-tests were performed for both paired and independent samples as appropriate.

There were two control conditions included to account for the alternative explanations that significant increases on posttest measures were due to soldiers' increased familiarity, gained during the course of their training session, with the test items and the computer delivery system. For each control condition participants completed pre- and posttests that were unrelated to the training they received. For the first control, participants in the land navigation group completed pre- and posttests on two remedial tasks--Using Visual Signals and Establishing Tank Positions--unrelated to their land navigation courseware. In the second control condition, soldiers from the remedial group completed pre- and posttests on a land navigation task--Identify Terrain Features--before and after their training and tests on the remedial tasks. The training and testing sequence for both the land navigation and remedial groups is provided in Table 1. Control conditions, in which pre- and posttests were unrelated to the training received, are also indicated. The training and tests for these two blocks of courseware, land navigation and remedial, were independent with no overlapping content. But the tests and training for each block of courseware were presented by the same computer delivery system.

Table 1

Training and Testing Sequence for Land Navigation and Remedial Groups

	Sequence				
Group	Pretest[a]	Pretest	Training	Posttest	Posttest[a]
Land Nav	Remedial	Land Nav	Land Nav	Land Nav	Remedial
Remedial	Land Nav	Remedial	Remedial	Remedial	Land Nav

[a]Indicates control conditions in which pre- and posttests were unrelated to training received.

Instruments

As noted above the primary instrument involved in this evaluation was the MicroTICCIT host computer and supporting work stations. All training courseware and all pre- and posttest measures for both groups were on-line products supplied directly by the MicroTICCIT system.

In addition a number of off-line instruments were also administered including a biographical questionnaire, a courseware evaluation questionnaire, and a student record sheet. The biographical questionnaire included a number of items concerning the participant's general military and educational background, computer experience end self-ratings for selected abilities (e.g., sense of direction). The courseware evaluation questionnaire contained a small number of open and closed-ended items that asked the participants to rate the overall training effectiveness of the courseware with respect to conventional land navigation training and to provide any recommendations they might have for improving the courseware. Finally the student record sheet which was maintained by the classroom proctors provided a data sheet for recording summary scores, time requirements for training and testing, and a log for recording system malfunctions, student problems and proctor interventions. Complete copies of each of these off-line instruments are provided in Appendix A.

Procedure

Soldiers were trained and tested individually as they worked at their assigned student work station. Prior to the training session each participant received a brief on-line introduction and orientation to the MicroTICCIT system. This introduction explained the organizational structure of the courseware and the supporting menu and prompt messages. In addition, this introduction familiarized students with the use of the light pen and the availability of an Advisor function to assist them through the courseware. All student inputs, requests and answers were entered by using a light pen. After each participant completed this orientation, pretests were administered for each task. Upon completion of all pretests, participants from the land navigation group began their training on the land navigation courseware, and participants from the remedial group, on the remedial courseware.

The training modules for each of the five land navigation tasks were developed with the same structure that, with only minor exceptions, included the objective, the instruction, a review, a help section, practice, and the pre-posttests (see Figure 2). While all participants were directed to complete the initial objective and instruction components, their training curriculum thereafter was determined by their self-selections and computer-based prompts. Instructional prompts based on the soldier's response and error patterns were provided by the on-line Advisor. For example, a student making an error on practice problems might automatically be referred by the Advisor to a related help component. After successfully answering a pre-set number of practice problems the student would be informed by the Advisor that he was probably ready to take the appropriate test.

The posttest for each task was administered immediately after the training for that task was completed. Participants then proceeded through training on the remaining tasks, maintaining the same train-test sequence. All participants were allowed to take short breaks at their discretion, but they were instructed not to discuss the training and test material until after they had completed all courseware and post-test measures.

After finishing all training and related posttests, participants were administered posttest(s) on the control task(s) for which they had received no training. All participants were then asked to complete a very brief courseware evaluation questionnaire, and the classroom proctors recorded any extended comments or recommendations they made about improving the courseware and training procedures.

Each soldier's session lasted approximately three hours depending upon the participant's pace in completing the training and testing requirements. Throughout the entire session, classroom proctors were present to assist students with any problems, input proctor functions for accessing the tests which were not directly accessible to students, and record both test scores and participants' comments.

Evaluation Measures

All criterion measures, the pre- and posttest scores, were generated from on-line courseware modules. Tests for each of the five land

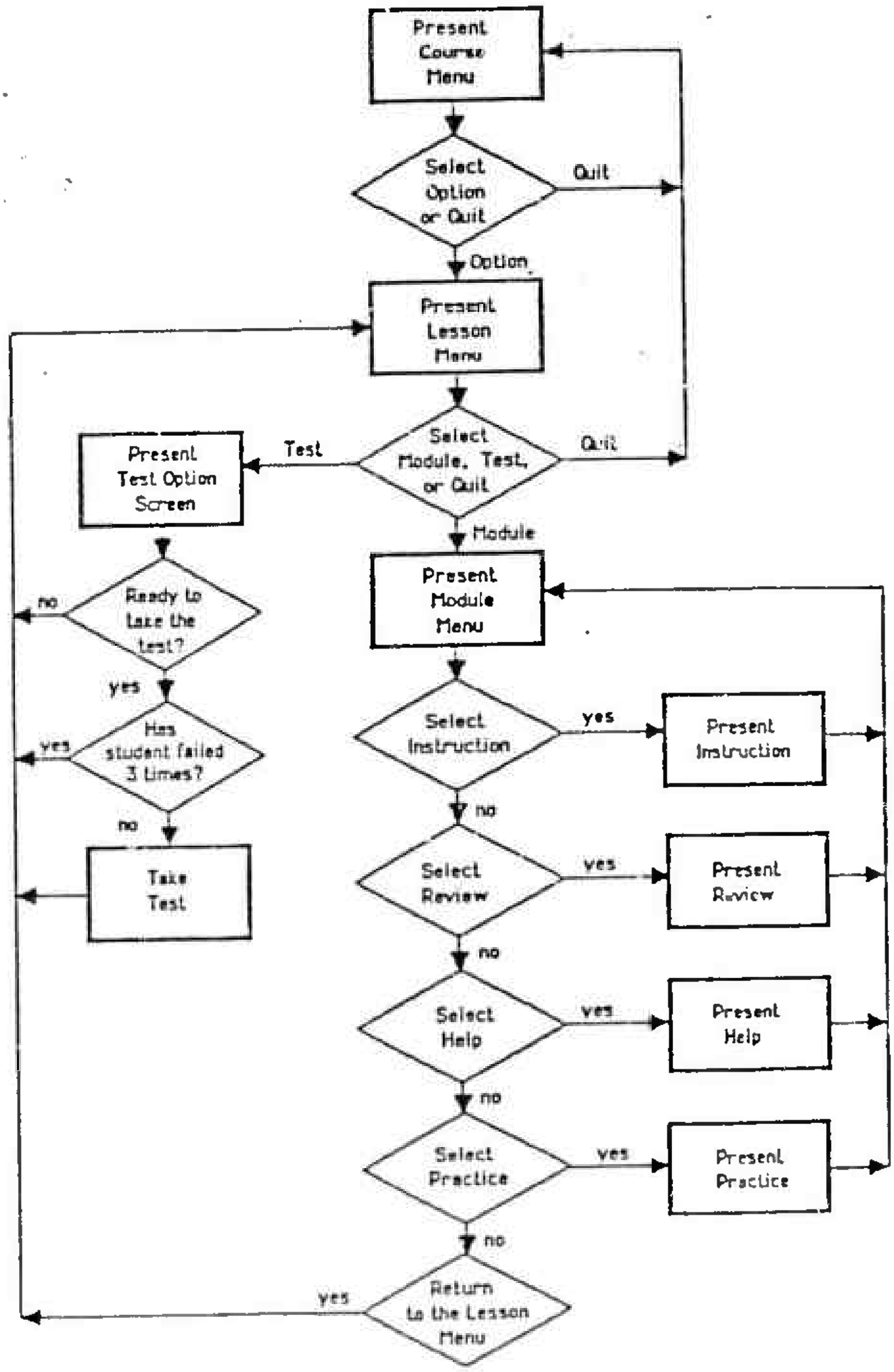

Figure 2. Flow chart for land navigation CBI courseware menus. From "Development of Interactive Videodisc Training for Army Land Navigation Skills" by L. Elder, C. Harris, P. Sticha, D. Stein, M. Knerr, and S. Tkacz, 1985, HumRRO Final Report 85-17, p. 16.

navigation and two remedial tasks contained close-ended multiple choice items. Students indicated their answers by selecting with the light pen their choice from among those response alternatives appearing on the monitor. Number of test items and choices per item varied as a function of courseware content and design. A brief description of each test is provided below.

Identify natural terrain features. This test consisted of 18 items of three different types. For six of the items students were presented a video image of a topographic map and a list of terrain feature labels (e.g., hill, spur, valley). Soldiers were required to select the feature name associated with the contour pattern that was highlighted by a graphic overlay. For six other items students were again provided the video image of a topographic map and a list of feature names, but now asked to mark the contour pattern on the map for a designated feature name. For the final six test items students were provided a video image of a topographic map and asked to determine the elevation of the terrain feature designated by a blinking arrow.

Determine a location on the ground by map terrain association. This test consisted of six items. Students were allowed to freely pan 360 degrees across videodisc images of the terrain, and then required to associate these features with those depicted around three different possible locations designated on their maps. Answers were input by selecting from the monitor one of the three locations (a, b, or c) similarly labelled on their paper map.

Orient a map to the ground by map terrain association. This six item test also provided students the capability of panning 360 degrees across videodisc images of the terrain and required them to associate these terrain features with those depicted on their paper map. Since the computer system could not detect the orientation of their paper map, students were asked to select any key terrain feature appearing on the video monitor and indicate its cardinal direction as portrayed on the corresponding paper map. Twenty-two directional choices (N, NNE, ENE, E, etc.) were depicted on a circular response panel graphically portrayed on the work station monitor. The standard for "correct" orientation was set at $\pm$ 30 degrees.

Locate an unknown point on the ground by intersection or resection. This 10 item test required students to designate the correct order of the procedures for intersection and resection. Soldiers were given a video image of a topographical map and an incomplete intersection or resection task (e.g., only one azimuth drawn from a key terrain feature to the unknown point) and asked to select the next procedural step for completing the task.

Analyze terrain using the five military aspects of terrain. This test consisted of 20 items of three difference types. For the first part students were required to list the five aspects of OCOKA (observation, cover and concealment, obtacles, key terrain, and avenues of approach) in the correct order. In the second part, students were required to match each of these aspects of terrain with their correct meaning or definition. For the third and final part, students were presented with color graphics of battlefield terrain scenes and asked to rate the OCOKA related advantages or disadvantages of a given aspect of the terrain.

Pre- and posttest scores were obtained by assigning one point to each item correctly answered. To ensure equivalent measures, identical items were used for both the pre- and posttests. For a more complete description of the test items and courseware description the reader is referred to Elder, Harris, Sticha, Stein, Knerr, and Tkacz (1985).

RESULTS

Tasks Not Trained

As previously discussed the research design for this evaluation was a pretest-posttest design in which the effects of training are based on improvements or gains in students' posttest scores over and above their pretest scores. Higher posttest scores, however, may have been due to students increased familiarity with the computer-based training delivery system and the test items and formats, rather than the training itself. To control for these potential effects each participant from the land navigation group completed on-line tests for two non-trained tasks before and after working with the land navigation courseware.

A summary of the data for these tasks not trained--Using Visual Signal and Establishing Tank Positions--is presented in the upper portion of Table 2. The average pre- and posttest scores for the Signals task were 11.02 and 11.45 and for the Position Task, 6.32 and 6.63. Paired comparison t-tests found no significant difference between the pre- and post scores for the Signals task, $t\ (43) = 1.61$, $p > .12$, or the Positions task, $t\ (42) = -.96$, $p > .30$.

More direct evidence for ruling out the effects of computer-experience on the land navigation posttests per se is provided by data from the remedial group also included in Table 2. The remedial group was tested, but not trained, on one of the land navigation tasks--Identify Terrain Features. The remedial group's pretest average of 10.78 and posttest average of 11.41 for this task were not significantly different, $t\ (38) = 1.48$, $p > .14$. These results for tasks not trained indicate that familiarity with the computer delivery system and the test items did not account for any significant improvements on the land navigation posttests.

Tasks Not Evaluated

Training courseware for two of the land navigation tasks--Determine a Location and Orient a Map by Terrain Association--were not formally evaluated due to inadequate courseware design. The design problem unique to both of these tasks was how to best display a 360-degree horizontal view of the terrain on a single workstation monitor, a TV screen. The solution attempted in the current courseware design was to simulate a

Table 2

Summary of Results for Tasks Trained and Tasks Not Trained

Tasks	Number of Soldiers	Number of Items	Pretest Average	Posttest Average	Gain Average
Not Trained					
Signals	44	16	11.02	11.45	.43
Positions	43	12	6.32	6.63	.31
Features[a]	39	18	10.78	11.41	.63
Trained					
Features	42	18	11.12	13.07	1.95
Location	44	10	2.86	7.48	4.62
Terrain	44	20	10.00	16.34	6.34

Note: Task titles refer in order to the following tasks: Communicate Using Visual Signals, Establish Tank Positions, Identify Terrain Features, Determine Location by Intersection or Resection, and Analyze the Five Military Aspects of Terrain.

[a]Indicates data from the remedial group.

visual pan across the terrain by rapidly accessing from the videodisc 120 sequentially stored video frames with each frame incrementing the pan by 3 degrees. While the pan simulation appeared realistic, soldiers were unable to integrate this linear set of frames into a circular (360-degree), composite view of the surrounding terrain. Soldiers were especially distressed by their inability to infer the angular displacement between terrain features that could not be simultaneously viewed on the monitor.

Students were having such difficulty with these tasks that Orient a Map was dropped from the evaluation during the pilot phase prior to the evaluation, and Determine a Location was eliminated during the first half of the four week evaluation cycle. Participants' frustration with these tasks was evident both in their posttest subjective evaluation of the courseware, and their posttest scores that were lower than their pretests. The experimenters decided that participants' frustration with these tasks might reduce their motivation on the other tasks and that it was unreasonable to force the students to work on these training modules. A more complete discussion of these tasks and proposed modifications to their courseware design are presented in the following section.

Tasks Trained and Evaluated

Training Effectiveness. Summary data for the three tasks formally evaluated--Identify Terrain Features, Intersection/Resection and Terrain Analysis--are presented in the lower portion of Table 2. The average pre- and posttest scores, respectively were 11.12 and 13.07 for Identify Features, 2.86 and 7.48 for Intersection/Resection, and finally 10.00 and 16.34 for Analyze Terrain. Paired comparison t-tests for each of these tasks found significant improvements in posttest performance. The t-test values and significance levels were 4.44 and .003 for Identify Features, 13.22 and .000 for Intersection and Resection, 11.98 and .000 for Analyze Terrain.

The courseware's training effectiveness for the latter two tasks--Intersection/Resection and Analyze Terrain--is apparent and would override any alternative explanation based on soldier familiarity with test items and the computer delivery system. For the other task--Identify Terrain Features--the paired comparison is significant, but not conclusive. Fortunately, the remedial group serves as a direct control for this task since they also completed its pre- and posttests without the benefit of feature identification training, and on the average four hours of remedial training on the same computer delivery system. A between group, land navigation versus remedial, t-test comparison of their gain scores for Identify Terrain Features was significant, $t\ (79) = 2.08$, $p = .041$. This finding of a significantly greater gain for the land navigation group effectively rules out alternative explanations of increased familiarity with test formats and/or the computer delivery system.

A more practical index of the courseware's training effectiveness is the relation of these pre- and posttest values to the POI standards for passing the 19K BNCOC course. Table 3 summarizes this comparison. In terms of "class" averages, participants began their training for each of these tasks at a failing or "No Go" level and completed their training at a passing or "Go" rate. Their relatively low pretest scores on Intersection/Resection and Terrain Analysis set the stage for remarkably large posttest gains. Similarly their relatively high pretest performance on Identify Terrain Features, may at least partially account for this training's more modest posttest improvement.

Table 3

Percentage of Test Items Correctly Answered: Comparison of Course Standard for Passing with Pretest and Posttest Results

Task	Standard	Pretest	Posttest	Gain
Features	70	62	73	11
Location	70	29	75	46
Terrain	80	50	82	32

Finally, soldiers themselves reported that the computer-based courseware was more effective than conventional training. On a 9-point rating scale their average effectiveness rating for this CBI was 6.95 (7.0 = "Effective") as compared to 6.27 for conventional land navigation training, $\underline{t}$ (40) = 2.52, $\underline{p}$ = .016.

Training Efficiency. Training efficiency is also a critical consideration in the evaluation of an applied training methodology. The data in Table 4 compare the training efficiency, in terms of time required to complete training and testing, of this computer based instruction (CBI) with the efficiency of the conventional program of instruction (POI). Data are presented for each of three tasks formally evaluated, and expressed in terms of minutes required for completion. CBI data were obtained directly from the computer delivery system and the POI data were extracted from the training schedules for the 19K BNCOC course cycle. On the average two hours were required to complete the CBI training and testing for all three tasks compared with five hours for the conventional POI.

Much of the efficiency, as well as the effectiveness, of CBI is due to individualized instruction. The land navigation courseware was designed to provide a training package that readily adapted to each student's entry level and ability. The Advisor function recommended to students when they were ready to take the test based on their performance with practice problems, or branched them back to the help and review components. The wide range of times required for students to complete their training and testing, less than 1 hour at a minimum to nearly 3.4 hours at the maximum, at least partially accounts for the courseware's training efficiency compared to the POI's conventional, lock-step schedule.

Table 4

Average Completion Times for CBI Training and Testing Versus POI

Task	CBI Range	CBI Total[a]	POI Total[a]	Gain
Identify	26-110	65	120	55
Locate	15-38	25	120	95
Analyze	13-55	30	60	30
	71-203	120	300	180

[a]Total indicates the time required to complete training and posttests, pretest times are not included because they are not performed in conventional training for BNCOC. All completion times are reported in minutes.

Ease of Training. Another major consideration in the evaluation of an instructional system is the soldiers' ease-of-use in adapting to the courseware's content, procedures, and requirements. Perhaps the most objective evidence of this courseware's usability is the reduced training time when combined with significant posttest improvements. But the participants' subjective evaluations of the courseware, from the Posttest Questionnaire, were also quite favorable. Frequently these comments were "easy to use", "explanations were clear and simple" and "better than a book". More telling comments with respect to the courseware's adaptability and student diversity ranged from "fast and to the point", "feedback was quick and direct" to "able to go back and review", "patient".

DISCUSSION

Effective Courseware

Results from the land navigation courseware modules tested during this evaluation demonstrate the potential for using innovative training technologies in an applied military setting. For each of the three tasks tested--Identify Terrain Features, Intersection and Resection, and Analyze Terrain--the courseware resulted in significant improvements in posttest performance. More relevant to the training goals, these were improvements that raised the average score for each of these tasks from "No Go" to "Go".

Several features of this evaluation should be noted that may have contributed to an underestimation of this courseware's training effectiveness. First, the fact that a representative sample of soldiers, rather than actual soldiers from 19K BNCOC, were used in this evaluation may have reduced the motivation and attentiveness typical of a student concerned with passing the course. Secondly, although the courseware's initial target audience is 19K BNCOC with soldiers averaging over 3 years of military training, more significant posttest improvements might be obtained with entry level personnel who must also be trained on land navigation skills. Finally, mastery learning was not required in this evaluation and posttest "Go" rates might have been significantly improved if soldiers receiving a "No Go" had been required to review and retake the posttest. All soldiers in 19K BNCOC are given three posttest opportunities for each task.

The courseware for each of these tasks also proved more efficient than conventional training procedures as evidenced by a 60% reduction in time required to complete the training. In addition, the courseware for each of these tasks proved remarkably easy for soldiers to use. The reduced training time, given training effectiveness, suggests that students had little difficulty mastering the basic interactive tasks required for utilizing the courseware. Ease-of-use is further evidenced by the fact that students showed no significant improvement on the posttests for tasks that were not trained. The fact that students scored as well on pretests for tasks not trained as they did on identical posttests, after several hours of interacting with the computer delivery system, suggests they quickly adapted to much of this automated training package.

Ineffective Courseware

For the two other tasks--Determine Location and Orient a Map by Terrain Association--developed as part of the land navigation courseware, results were not favorable.

The design problem unique to both of these tasks is the requirement to maintain orientation of a 360-degree horizontal pan of the terrain when presented on a single monitor with its limited field-of-view. The requirement is analogous to a tank commander's task of viewing the terrain while looking through an isolated vision block as the tank's turret is rotated. This formidable requirement in the tank environment is compounded in the current courseware design by the absence of correlated vestibular cues, since the viewer remains stationary and the terrain rotates. Each of the courseware's 360-degree pans of the terrain were based on 120 video frames that incremented the soldier's field of view by 3 degrees as he "rotated" to view the surrounding landscape. Even when soldiers were able to identify, or associate, two or more terrain features with those depicted on the topographic map, they had great difficulty inferring the angular displacement between these features.

In anticipation of this problem, the courseware designers included an icon of a moving arrow on the display that continually updated the angular distance the subject had rotated from the initial frame. At the termination of each pan (from 0 degrees to 360 degrees) initiated by the student, the arrow rotated and depicted the angular displacement between the student's current view and his initial view of the terrain. This solution was inadequate.

Courseware Modifications

Is there a solution to this problem given the hardware configuration, one display monitor per student workstation, of the current courseware? Other technologies are available for providing a simultaneous 360-degree horizontal view of the terrain, but they are not consistent with TTFA's goals of providing low cost, self-paced and readily transferable training methodologies. For example, ARI-Fort Benning has developed a training device called SURNOT (Surface Navigation and Orientation Trainer) that utilizes a fish-eye lens for photographing and projecting 360-degree perspective fields of view (Dewey and O'Hanlan, 1986). SURNOT would appear to be an excellent training device for these tasks, but its current hardware configuration does not meet any of the TTFA goals previously discussed.

Based on students' suggestions and the experimenters' observations several recommendations for reducing this disorientation while maintaining the current delivery system are being pursued. These recommendations focus primarily on redesign of the workstation's control panel by which the student directs the panning sequences. One alternative design is to replace the moving arrow graphic with a generic compass overlay by which students could directly select angular displacements of interest. The compass is generic in that it provides only relative direction and relative angular displacements, since more absolute bearings such as cardinal directions would circumvent the purpose of the task. The configural nature of this graphic, as opposed to the discrete arrow indications, would provide soldiers a frame of reference for mentally computing the angular displacement between selected features. In addition, as the user's control panel, this compass would maximize the random access capability of the videodisc and allow users to rapidly or even directly shift from one view of the terrain to another without examining all the intervening frames on the videodisc. While this exclusion of intervening terrain might appear disruptive, it is consistent with the natural processing of perceptual information. When a viewer rapidly shifts the direction of gaze, only the original and final views are perceived in detail. This and several additional design modifications for the courseware in general are being developed in a follow-up effort to this evaluation.

Courseware Implementation

Based on the results of this evaluation, recommendations for courseware implementation were made to the TTFA management team. The first recommendation was that the computer and videodisc-based land navigation courseware for three tasks formally evaluated--Identify Terrain Features, Determine a Location by Intersection or Resection, and Analyze Terrain--be validated for the basic POI of 19K BNCOC. The second recommendation was that the courseware for the other two tasks--Orient a Map and Determine Location by Map Terrain Association--not be validated until courseware design modifications for these tasks had been made and formally evaluated. Acting on these recommendations, validation trials have been scheduled for those tasks recommended. The validation trials, described below, are the final TTFA evaluation prior to courseware implementation.

For the validation trials, actual students from the 19K BNCOC course are used as participants and all instructor and proctor functions are performed by the 19K BNCOC course instructors, rather than the TTFA and ARI support personnel used during this evaluation. In addition the validation trials are designed to provide a more direct comparison between the training effectiveness of the computer and videodisc-based instruction (CBI) with the conventional training from the current program of instruction (POI). Due to 19K BNCOC's limited class size, 12-15 students, the validation trials will be conducted over several course cycles to provide a sufficient data base.

The validation trials were initiated during the first regular course cycle following this evaluation and the results, although preliminary, are favorable. One half (6 students) of the class received their land navigation training on the computer and videodisc-based courseware. They then completed posttests on this system, and on the conventional paper and pencil test formats currently used in the course. All of these students passed both the CBI and POI tests on their first trial, with the exception of one student on one of the tasks for both mediums. If the remaining validation trials prove as successful, they will set the stage for implementation of this courseware into 19K BNCOC.

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APPENDIX A
EVALUATION INSTRUMENTS

BIOGRAPHICAL QUESTIONNAIRE

Subject # ________________ Date ____________________

Social Security # ____________________ Rank E - ____ O - ____

1. How long have you been in the service? ____ years ____ months

2. How old are you? ____ years ____ months

3. What is your primary MOS/SC? ________

4. What is your secondary MOS/SC? ________

5. What is your current Unit? ________

6. Please check each of the following courses you have attended:

   PLDC ____ BNCOC ____ ANCOC ____ AOC ____ AOAC ____

7. Check each of the following statements that are true for you.

____ I have no previous experience with computers.
____ I frequently play video games.
____ I own a home computer.
____ I have received formal training on how to use a computer.
____ I have previously participated in training delivered by a computer.
____ I have a lot of experience with computers.

8. What is your highest academic level completed? (Check one below.)

   High School ____ GED ____ Some College ____ College Graduate ____

9. How would you describe your "handedness" or preferred hand? (Check one below.)

   Right handed ____ Left handed ____ Both hands ____

10. How would you rate your "sense of direction", your ability to maintain your orientation? Please circle the number below (1-9) that best describes your sense of direction.

1	2	3	4	5	6	7	8	9
Extremely Poor Direction		Poor Direction		Average Direction		Good Direction		Extremely Good Direction

11. How would you rate your ability to perform terrain visualization, that is your ability to associate terrain and cultural features with those depicted on the topographic map? (Please circle the number below that best describes your terrain association abilities.)

1	2	3	4	5	6	7	8	9
Extremely Poor Association		Poor Association		Average Association		Good Association		Extremely Good Association

12. Would you say that you were raised more as "country" boy or as a "city" boy? (Please circle a number below that best describes your background.)

1	2	3	4	5	6	7	8	9
Country Boy		Mostly Country		Half Country Half City		Mostly City		City Boy

13. In general how would you rate your ability to perform military land navigation tasks. Please circle the number below (1-9) that best describes your ability as a navigator.

1	2	3	4	5	6	7	8	9
Extremely Poor Navigator		Poor Navigator		Average Navigator		Good Navigator		Extremely Good Navigator

14. How long has it been since you last had the opportunity or requirement to perform some land navigation tasks in a field setting? Please check one of the times below.

____ Less than 6 months

____ 6 months to a year

____ 1-2 years

____ 3-5 years

____ more than 5 years

PT 5680

POST TESTING QUESTIONNAIRE

Subject # ____________________ Date ____________________

We would like to ask you a few final questions about how you would evaluate this computer assisted training that you have just experienced.

1. In general what did you like best about this computer-assisted training? Please briefly write your answer below.

2. In general what did you least like about this computer-assisted training? Please briefly write your answer below.

3. Now we would like you to rate the effectiveness of this computer assisted training. How would you rate the overall training effectiveness of the instruction you have just completed for training land navigation skills? Please circle the number below (1-9) that best indicates your evaluation of the instructions training effectiveness.

1	2	3	4	5	6	7	8	9
Very Ineffective Training		Ineffective		Average Effectiveness		Effective		Very Effective Training

4. In comparison, how would you rate the training effectiveness of the standard or "conventional" instruction provided for land navigation. Based on your military training please circle the number below (1-9) that best indicates your evaluation of the conventional land navigation training.

1	2	3	4	5	6	7	8	9
Very Ineffective Training		Ineffective		Average Effectiveness		Effective		Very Effective Training

5. What could be done to improve this training? Please write suggestions below.

PT 5680

PROCEDURES FOR LAND NAVIGATION TRIALS

1. Give students an orientation to the day's activities. Cover the following points:

a. Explain the purpose of the study; this is to test computer-based training for BNCOC before using it in the course. Tell students that no record of their performance will be maintained or returned to their unit. But they should still do the best they can with the computer-based training, since they may get some useful training out of it and their performance will affect what they will see in BNCOC someday. Motivate the students to give an honest effort.

b. Give the students an overview of the day's activities. Explain that they will take a series of tests on the computer followed by training and retests. Tell them to raise their hands or call you before they start a block of instruction or a test, and when they have problems. Tell them not to be frustrated by the initial tests, but to do the best they can.

c. A few remarks about scoring and "not doing well". First, some of the problems may be very difficult and the standards for determining "correct" vs "incorrect" and "Go" vs "No-Go" are in some cases too demanding. Don't worry about how the machine "scores" your performance, this is being evaluated also. Second, we are asking you to take the land navigation tests before you receive any land navigation training. This is not standard training procedure but only a requirement for this particular evaluation. So don't be to concerned about scores, just do the best you can.

d. Cover administrative points and answer student's questions. Explain that breaks and lunch period will be taken as needed (within reason). Emphasize that you are available to help them, but you will not tell them the answer or coach them.

2. Assign student numbers. Training and posttest number should always be 100 higher than pretest number. The operator should already have registered students under these numbers.

3. Administer the biographical questionnaire to each student. Be available to help them complete it.

4. Move the students to MicroTICCIT work-station. Place each student's record sheet at his work-station. Try to ease any fear they have of the computer. Show them how the light-pen works and have them take the TUTORIAL. Advise them not to use the keyboard and move the keyboard aside.

5. After they have completed the TUTORIAL, answer their questions and give them an overview of how to move through the instruction. First, they will take all the tests; then they will take instruction, practice, and test for each task. Re-emphasize that they are to notify you when they are ready to start a block of instruction or a test. Also, tell them that you need to see the screen providing feedback on the results of each test. They should not advance past their screen until you have seen it and copied the necessary information. Let them begin.

6. Monitor students, recording their times, scores, and significant problems on the record sheets. Be helpful but do not over-coach.

7. Remember to change videodiscs after completion of two remedial pretests.

8. Remember to turn videodisc over between "identify features/determine elevation" and other tasks during land navigation pretesting and training. Training and tests for land navigation tasks are as follows:

Land Nav Video Disc

Side 1	(Facing Down on Player)	Side 2	(Facing Down on Player)
Identify Terrain	Tng and Test	Orient a Map	Tng and Test
Determine Elevation	Tng and Test	Determine Location	Tng and Test
		Intersection/Resection	Tng and Test
		Analyze Terrain	Tng and Test

9. Remember to change videodiscs before completion of two remedial posttests.

10. If any student is running short on time, skip the training and posttest on "intersection/resection" or "analyze terrain" or both, if necessary. If you delete one, try to alternate which one you skip so that we get roughly the same number of students on each. Don't work student longer than 8 hours, not counting the lunch break. Remember: the operator needs time to "back up" the system.

11. Administer the posttest questionnaire to each student. As time allows, encourage them to comment on the training and record any useful comments they make. Thank them and send them on their way.

INSTRUCTIONS FOR STUDENT RECORD SHEET LAND NAVIGATION TRIALS

1. Enter student numbers at top of sheet. Student's number for training and posttest is always 100 higher than his pretest number. For example, the first student is #1 for pretest and #101 for training and posttest.

2. Provide student and evaluator with the correct testing and training SEQUENCE based on ODD or EVEN assigned student number.

3. Enter time started and time ended each time student starts or completes training or test. Have students raise hands to indicate a start or completion. Under Land Navigation Training and Tests, enter 2 (two) start and 2 (two) end times, one for training and one for test. If student fails to complete training or test, enter time stopped.

4. Enter one of the following codes for each test result: G-Go, N-No Go, I-Incomplete. Also enter number of items correct and total number of items on test under Test Score (e.g., G/9 of 12).

5. Each time a problem arises which requires your intervention, enter a code in the last column indicating the nature of the problem. If further explanation of the problem and its solution is required, put a number beside the code and write a corresponding footnote on a separate page. Codes are as follows:

Personnel

SI - student cannot follow instructions for interacting with computer
SC - student cannot comprehend material presented
SP - student has personal problem interfering with training
SO - other
SU - unknown

Equipment

ESH - system-wide (host) MicroTICCIT malfunction
EWS - malfunction in individual work-station processor or monitor
EVD - problem with videodisc player or videodisc availability
ETM - lack of necessary paper-based training materials
EO - other
EU - unknown

For EVEN numbered students

STUDENT RECORD SHEET FOR LAND NAVIGATION TRIALS

Student number: Pretest # ________ Tng + Posttest # ________

SEQUENCE	Pretest G or NG	Pretest #Rt/#Tried	Postest G or NG	Postest #Rt/#Tried	Problem/Solution
Remedial					
Tank Positions (12)	____	___/___	____	___/___	___/___
Visual Signals (16)	____	___/___	____	___/___	___/___
Land Navigation Pretest					
Analyze Terrain (20)	____	___/___	____	___/___	___/___
Intersection (6)	____	___/___	____	___/___	___/___
Resection (4)					
Identify Features (12)	____	___/___	____	___/___	___/___
Determine Elevation (6)	____	___/___	____	___/___	___/___
Remedial					
Tank Positions (12)	____	___/___	____	___/___	___/___
Visual Signals (16)	____	___/___	____	___/___	___/___

Second Session			
Determine Location (6)	____	___/___	___/___

PT 5680

For ODD numbered students

STUDENT RECORD SHEET FOR LAND NAVIGATION TRIALS

Student number: Pretest # ________ Tng + Posttest # ________

SEQUENCE	Pretest G or NG	Pretest #Rt/#Tried	Postest G or NG	Postest #Rt/#Tried	Problem/Solution
Remedial					
Visual Signals (16)	____	____/____	____	____/____	____/____
Tank Positions (12)	____	____/____	____	____/____	____/____
Land Navigation Pretest					
Identify Features (12)	____	____/____	____	____/____	____/____
Determine Elevation (6)	____	____/____	____	____/____	____/____
Intersection (6)	____	____/____	____	____/____	____/____
Resection (4)	____	____/____	____	____/____	____/____
Analyze Terrain (20)	____	____/____	____	____/____	____/____
Remedial					
Visual Signals (16)	____	____/____	____	____/____	____/____
Tank Positions (12)	____	____/____	____	____/____	____/____

SEQUENCE	Pretest G or NG	Pretest #Rt/#Tried	Postest G or NG	Postest #Rt/#Tried	Problem/Solution
Second Session					
Determine Location (6)			____	____/____	____/____